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RADIUM

EDITED BY
CHARLES H. VIOL, Ph. D.
AND
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VOL. XIII AUGUST, 1919 No. 5

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A MONTHLY JOURNAL DEVOTED TO THE CHEMISTRY PHYSICS AND THERAPEUTICS OF RADIUM AND RADIO-ACTIVE SUBSTANCES

RADIUM

A MONTHLY JOURNAL DEVOTED TO THE CHEMISTRY, PHYSICS AND THERAPEUTICS OF RADIUM AND RADIO-ACTIVE SUBSTANCES

Edited and Published by Charles H. Viol, Ph. D., and William H. Cameron, M. D. with the assistance of collaborators working in the fields of Radiochemistry, Radioactivity and Radiumtherapy.

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VOL. XIII AUGUST, 1919 No. 5

A REPORT OF THE WORK CARRIED OUT AT THE RADIUM INSTITUTE, LONDON

From January 1st, 1918, to December 31st, 1918.*

By

A. E. HAYWARD PINCH, F.R.C.S.

Medical Superintendent

The report of the work of the Radium Institute for 1917 was devoted principally to a consideration of the results obtained to date in the treatment of malignant disease, and contained details of many cases illustrative of the procedures adopted and the effects produced, together with notes as to the length of time that the patients had remained free from their disease.

The report for 1918 will, therefore, be confined mainly to a description of non-malignant conditions, war-time injuries, and diseases of unusual type, or infrequent occurrence which have proved amenable to radium therapy.

A general review of the present-day position of the radium treatment of malignant disease is also given, but reference should be made to the report for 1917 if more specific information be desired.

The Summary of Cases refers only to those patients who were seen for the first time during the period from the 1st January, 1918, to the 31st December, 1918, and does not include any cases examined prior to those dates, though many such have received treatment during 1918.

The group "Examined but not treated" comprises:—

(a) Cases unsuitable for radium therapy.

(b) Cases which were practicaly moribund.

*In this number of RADIUM is reprinted that portion of the Report which includes the general summary of cases and the discussion of the treatment of malignant growths, lymphatic and splenic leukemia. In the forthcoming number of RADIUM the Report will be concluded. Ed.

(c) Cases of malignant disease which were manifestly operable—rodent ulcer alone excepted.

With reference to the column "Recent report not yet received," due note must be taken of the fact that the exigencies of the Naval and Royal Army Medical Services have occasioned many alterations in the conduct of practices, which have rendered it often extremely difficult, or even impossible, to obtain reliable information concerning patients.

The term "apparent cure" used in relation to cases of malignant disease, must be interpreted as representing a condition in which all traces of the original lesion or lesions have disappeared, in which there is no sign of any recurrence, and in which the patient is, so far as can be determined by a thorough and careful examination, free from any indication or symptom of the disease.

Cases have been classed under the heading "improved" only when the result of the treatment has been to produce a definite degree of benefit, either in retardation of the progress of the disease, diminution in the size of the growth, healing of ulceration, and arrest of hæmorrhage or discharge; or relief from such subjective symptoms as itching, tenderness, pain, aphonia, dyspnœa or dysphagia.

The strength of all the apparatus used in the treatment of cases is expressed in terms of hydrated radium bromide, a salt the radium element content of which is 53.6 per cent.*

A "full-strength" applicator contains 10 mgr. to each square centimetre of surface.

A "half-strength" applicator contains 5 mgr. to each square centimetre of surface.

"A quarter-strength" applicator contains 2.5 mgr. to each square centimetre of surface.

No description of apparatus and technique is given this year, as information on these points can be obtained by reference to the reports published in 1913, 1914, and 1915.

TABLE *I.*

Summary of Cases.

Examined but not treated	61
Recent report not received	91
Prophylactic treatment only	20
Apparently cured	103
Cured	27
Improved	288
Not improved	82
Abandoned treatment	28
Dead	43
Total	743

6,623 treatments were administered during the year, of which 4,163 were given free of charge to necessitous patients.

789 emanation applicators were prepared during the year, of these 417 were distributed gratuitously to hospitals and medical practitioners.

THE TREATMENT OF MALIGNANT DISEASE.

Increasing experience and careful observation have led to the employment of much larger quantities of radium than was at first thought

*It is important to bear this in mind since in the United States dosage is commonly based on the radium element content. Ed.

TABLE II.

Classification of Cases.

DISEASE.	Examined, but not treated.	Recent report not received.	Received prophylactic irradiation only	Apparently cured.	Cured.	Improved.	Not improved.	Abandoned treatment.	Dead.	Total.
Carcinoma, Squamous-celled:										
Glabrous skin	1	2	1	4	—	1	1	1	—	11
Buccal, oral, lingual and pharyngeal mucous membrane	12	10	5	1	—	—	12	10	5	71
Oesophagus	3	1	—	—	—	2	1	—	2	9
Larynx	—	1	—	—	—	4	1	—	3	9
Vagina and vulva	2	1	—	1	—	2	2	—	—	8
Uterus	6	6	—	1	—	21	6	2	3	45
Bladder	—	3	—	—	—	2	1	—	3	9
Urethra	—	—	—	1	—	1	—	—	—	2
Carcinoma, Spheroidal-celled:										
Breast	5	12	7	3	—	52	13	4	9	105
Liver	1	—	—	—	—	1	1	1	—	4
Carcinoma, Columnar-celled:										
Large intestine	—	—	—	—	—	—	—	1	—	1
Rectum	2	7	—	—	—	14	1	1	5	30
Stomach	—	1	—	—	—	2	1	—	—	4
Ovary	—	1	—	—	—	—	—	—	—	1
Prostate	—	—	—	—	—	4	—	—	—	4
Rodent ulcer	1	5	1	68	—	33	1	1	2	112
Sarcoma:										
Spindle-celled	—	—	2	1	—	4	3	1	1	12
Round-celled	—	2	2	1	—	8	—	1	2	16
Melanoma	—	—	—	1	—	1	3	—	1	6
Lymphosarcoma	—	—	1	4	—	6	—	—	1	12
Endothelioma	1	2	—	3	—	3	2	1	—	12
Glioma	—	—	—	—	—	—	—	—	1	1
Lymphadenoma	2	1	—	1	—	3	—	—	1	8
Malignant glands	—	1	—	—	—	3	3	1	—	8
Parotid tumor	1	2	—	—	—	2	1	2	—	8
Abdominal tumor	—	1	—	—	—	—	1	—	—	2
Mediastinal tumor	—	2	—	—	—	4	1	—	3	10
Sacro-coccygeal tumor	1	—	—	—	—	1	—	—	1	3
Villous tumor of bladder	—	2	—	—	—	3	—	—	—	5
Adenoma (rectum)	—	—	—	—	—	1	—	—	—	1
Neuroma	—	—	—	—	—	—	1	—	—	1
Fibroma	—	—	—	—	—	—	1	—	—	1
Fibroid disease of uterus	1	3	—	1	—	1	1	—	—	7
Leucoplakia	—	—	—	3	—	4	—	—	—	7
Granulomata	—	1	—	2	—	2	—	—	—	5
Exophthalmic goitre	1	—	—	—	—	2	—	—	—	3
Naevi:										
Capillary	—	—	—	—	2	9	1	1	—	13
Cavernous	—	1	—	—	4	9	—	—	—	14
Moles, warts and papillomata	2	1	—	—	10	1	—	—	—	14
Tuberculosis:										
Mucous membrane	—	—	—	—	—	2	—	—	—	2
Skin	—	1	—	6	—	12	1	—	—	20
Skin diseases:										
Lichenification	—	—	—	—	2	1	—	—	—	3
Chronic eczema and hyperkeratosis	—	1	—	—	2	2	—	—	—	5
Psoriasis	—	—	—	—	—	1	—	—	—	1
Mycosis fungoides	—	—	—	—	—	1	—	—	—	1
Xanthoma	—	—	—	—	2	—	—	—	—	2
Xerodermia pigmentosum	—	—	—	—	—	1	—	—	—	1
Pruritus	—	—	—	—	1	—	1	—	—	2
X-ray dermatitis	—	—	—	—	—	2	—	—	—	2
Keloid and vicious cicatrices	3	5	—	—	4	24	16	—	—	52
Lupus erythematosus	—	—	—	—	—	1	—	—	—	1
General diseases:										
Splenomedullary leukaemia	1	—	—	—	—	1	—	—	—	2
Neuritis	—	1	—	—	—	—	1	—	—	2
Arthritis deformans	3	9	—	—	—	18	3	—	—	33
Chronic inflammations	—	1	—	1	—	—	1	—	—	3
Various	12	4	1	—	—	—	—	—	—	17
Totals	61	91	20	103	27	288	82	28	43	743

advisable or justifiable, and in many cases the use of apparatus containing 1 gramme or more of radium for a comparatively short period, will produce results which are more rapid in their appearance and more permanent in their duration than those following upon prolonged exposures with much smaller amounts.

This occurrence is, perhaps, best seen in patients who are suffering from lymphadenoma, lympho-sarcoma, and mediastinal growths of a sarcomatous nature. The employment of this short intense dosage is, however, almost invariably provocative of considerable systemic disturbance, from the production of an auto-toxæmia, and shortly after the treatment the patients begin to suffer from languor, exhaustion, loss of appetite, nausea—perhaps even vomiting—and some rise of temperature. These symptoms, however, prove quite transient, and disappear in two or three days, the patients' recovery therefrom being expedited by rest in bed, appropriate feeding, and the judicious administration of laxatives and diuretics.

The employment of emanation tubes has been largely extended, and by virtue of the possibility of concentrating in them the unit of activity to a very high degree, they are of great value for the treatment of inoperable recurrent nodules or primary growths, especially when situated in positions which render treatment with external applicators impracticable or inadvisable. The screening usually adopted is 1 mm. of silver, the secondary radiation from this metal being much less intense than that from platinum or lead, and not producing so definite a local necrosis in the layer of tissues in immediate contact with the tube. Great caution must be observed in dealing with growths of the parotid, and it is always advisable to try first the effect of external radiations only, as the track left by the withdrawal of an emanation tube, especially if the reaction has been a severe one, shows a remarkable tendency sooner or later to form a sinus which is kept open by the digestive action of the parotid secretion and constitutes an area from which ulceration of the tissue starts, spreads slowly, and defies all efforts to arrest it.

Carcinoma.

Squamous Celled (Epithelioma).

These growths, when of small size and situate on the glabrous skin, are best treated by short intense exposures with full-strength plates applied without screen. The duration has to be proportioned to the thickness of the lesion, and may vary from one to three hours. A definite destructive reaction extending well beyond the margins of the tumor should be produced. With the subsidence of the reaction, a depressed white, supple scar appears at the site of the growth.

Large flat superficially ulcerated epitheliomata without much subjacent induration respond most favorably to treatment with quarter-strength applicators, screened with 1/10 mm. of lead, an exposure of six hours' duration being given on each of three successive days, the series being repeated in six weeks' time if necessary.

Extensive epitheliomatous masses with much surrounding induration and infection of the neighboring lymphatics afforded but little prospect of cure, but if inoperable may be treated by prolonged exposures of thirty hours or more in duration to the penetrating gamma radiation obtained by the use of heavily screened applicators. The burying of emanation tubes screened with 1 mm. of silver in the substance of the growth may often be employed advantageously in addition, but considerable discretion must be exercised, as, by reason of the avascularity of these tumors, too

intense a dosage results in gross necrotic changes, with increase of any existing ulceration.

Epitheliomata of the buccal mucous membrane, tongue, and fauces, must be regarded as most unsatisfactory in their general response to radium therapy, and though in some few instances—more especially small circumscribed growths of the solt palate—complete fibrosis or disappearance of the tumor follows upon the insertion of a tiny powerful emanation tube screened with 0.3 mm. of platinum for six to ten hours, yet in by far the larger number of cases but little real benefit is ever observed.

Epithelioma of the œsophagus is frequently much benefited by radium treatment, if taken in its early stages, and before the stricture has become impermeable to the passage of anything but liquids. A tube of 100 mgr. activity screened with 1 mm. of silver is passed under direct œsophagoscopy into the lumen of the stricture, and maintained in this position by means of a pliable silver wire for from fifteen to eighteen hours. The immediate result of this treatment is usually improvement in the power of swallowing, but this is due only to the mechanical effects of the tube acting as a dilator of the stricture. In five or six days' time, however, with the onset of the reaction, the growth and neighboring tissues becoming swollen and congested, the dyshagia is more pronounced. As the reaction subsides, some degree of fibrosis occurs with a resultant shrinking of the growth, and accompanying lessening of the obstruction. In favorable cases the dysphargia may be so much relieved that the patient is able to swallow solid food for six, nine, or even more months, after the termination of his reaction.

Carcinoma of the uterus, if inoperable, is usually more benefited by radium therapy than by any other form of medical or surgical treatment, the local and symptomatic improvement being most rapid and striking. Arrest or delay of the direct extension of the disease also occurs, but it is doubtful whether any very great retardation of dissemination through the lymphatics takes place. If the cervical growth be of an exuberant or cauliflower type, removal of as much as possible by excision, curettage, or cautery is advisable before commencing the radium treatment. The employment of a powerful heavily screened radium plate applied over the fundus of the uterus, in addition to the intra-vaginal or intra-cervical use of radium tubes, is strongly to be advocated, as in this fashion a very thorough irradiation of the whole disease area is obtained.

Small circumscribed nodular growths situate in the cervical or vaginal walls may be treated advantageously by the introduction of powerful emanation tubes screened with 0.3 mm. of platinum into their substance for periods of from ten to fifteen hours.

In operable cases, where hysterectomy is contemplated, thorough radiation of the whole diseased area a month or six weeks prior to the operation will often serve greatly to diminish the ulceration and lessen the perituerine infiltration, so that the removal of the uterus can be much more satisfactorily performed.

Carcinoma of the Bladder.—Whenever practicable, this condition should be treated both by the introduction of radium into the bladder and by screened applicators placed externally above the pubes, on the perinæum, and in the vagina or rectum, as by these means a very effective cross-fire irradiation can be obtained.

With female patients the intra-vesical treatment presents no difficulty, the urethra being short, straight and readily dilated. In male sub-

jects, however, the presence of an urethral stricture or much enlarged prostate often renders the introduction of radium into the bladder difficult or impossible. If the presence of a malignant growth of the bladder has been rendered evident by supra-public cystotomy, the intra-vesical treatment should be carried out through the supra-public opening before it has closed. A tube of 50 mgr. activity, screened with 1 mm. of silver, should be employed, and a total exposure not exceeding twelve hours in duration, spread over three or four days, given. For the external treatment, the use of apparatus containing in all 300 to 500 mgr. screened with 2 mm. of lead, with a total exposure of from twenty-four to thirty-six is indicated. In not a few instances, treatment on these lines has been followed by a rapid disappearance of the hæmaturia, and all other troublesome symptoms, accompanied by shrinking and fibrosis of the tumor, and an "apparent cure" of the disease.

SPHEROIDAL CELLED CARCINOMA.

Carcinoma of the breast forms an exceedingly large proportion of all the cases of malignant disease treated at the Institute, and every possible variation is met with, from the tiny recurrent nodule adherent to the ribs or sternum, to the most extensive condition of "cancer en cuirasse." For this reason, therefore, the results of radium treatment vary within very wide limits.

The complete disappearance of recurrent nodules is of comparatively frequent occurrence, more especially when the growth is of small size, and so situate that treatment by the burying of an emanation tube is practicable.

When a wide area of the skin is involved, or the axillary and supra-clavicular lymphatic glands enlarged, with much surrounding induration, recourse must be had to the employment of numerous powerful applicators screened with 2 mm. of lead, and containing in all a quantity of radium bromide amounting to half a gramme, one gramme, or even more.

The susceptibility of individual patients to this method of treatment is by no means uniform or constant, and up to the present it has proved impossible to predict the result in any particular case, though, speaking generally, greater benefit is likely to occur in patients of spare physique over fifty years of age than in young and corpulent subjects.

Cases of atrophic type occurring in elderly women do well under prolonged screened exposures, the rate of progress being checked and the disease rendered quiescent for many months or years.

Carcinoma of the Thyroid Gland.—Since these growths exhibit a very striking tendency to fungation when once any breach of continuity of the skin investing them has occurred, it is inadvisable to attempt their treatment by the use of buried radium tubes, and resort should be had only to external applicators. The response is usually extremely rapid and striking, a very great decrease in the size of the tumor often being apparent within a week of the exposure. The disease may often be much retarded, or even rendered quiescent for a period of one, two, or more years, but the tendency to internal dissemination does not seem to be wholly eliminated, and the appearance of secondary metastatic deposits in the viscera or bones may take place after a very long interval.

COLUMNAR-CELLED CARCINOMA.

Carcinoma of Stomach and Intestines.—In inoperable or recurrent cases of this disease, the employment of radium is justifiable for the purpose of checking the rate of growth, and ameliorating the symptoms, though this is the utmost benefit that can be expected.

The treatment of this condition demands the employment of numerous powerful applicators, heavily screened, the total duration of the exposures being thirty, forty or more hours.

Carcinoma of the Rectum.—This disease exhibits many curious variations in its response to radium therapy, and it is extremely difficult to predict the amount of benefit likely to occur in any one instance. Speaking generally, however, those growths which are situate in the upper half of the rectal ampulla are more amenable than those nearer to or affecting the anal canal.

The exuberant, vascular annular class of growth is also much more favorably affected than the plaque-like and infiltrating type.

Proctitis often proves very troublesome, more especially in men, being produced by the action of the radium rays on the healthy rectal mucous membrane. Protection of the unaffected portions of the rectal wall by the interposition of gauze packing will help to diminish the probability of its occurrence.

In "border line" cases, radium treatment not infrequently effects so great a decrease in the size of the growth, and lessening of the surrounding induration, that its excision may be easily and satisfactorily accomplished, and it is in this class of rectal growth particularly that radium treatment may be advocated most strongly.

Radium therapy may also be employed with considerable advantage after the performance of colostomy, as it will serve to arrest hæmorrhage, lessen ulceration, and retard the spread of the disease to the bladder or vagina.

Carcinoma of the Prostate.—The progress of this disease is often retarded, and the distressing sympatoms relieved, by appropriate radium treatment.

If the disease be confined to one lobe, forming a definite circumscribed nodule, the use of a powerful emanation tube screened with 1 mm. of silver, and buried in the growth for twenty-four hours is to be recommended; but when the condition is generalized, treatment is best carried out by means of an emanation tube with an initial activity of about 75 mgr. screened with 1mm. of silver, and inserted in the penultimate portion of a bi-coude catheter. This is placed in the prostatic urethra, and exposures of two hours' duration given on each of four or five successive days. This is supplemented by the use of powerful screened applicators placed over the perinæum, and a 100 mgr. tube screened with 2 mm. of lead and 3 mm. of rubber being placed in the rectum in contact with the base of the prostate.

The perineal and rectal exposures should be of from twenty-four to thirty hours' duration, spread over five or six days.

Sarcomata.

Tumors of a sarcomatous nature if treated vigorously at an early date, or before dissemination into the internal viscera has taken place, often respond in a most striking manner. Heavy dosage should be employed, and whenever possible the use of both buried tubes and external applicators adopted.

These growths being extremely vascular, necrotic changes are not so likely to occur as in the case of epitheliomata, and the stimulent action of the radium rays upon the tissue fibro-blasts results in the production of much new fibrous tissue, which invades the sarcomatous masses of cells, compressing them and causing their degeneration, the tumor ultimately becoming converted into a greatly diminished dense fibrous mass. This

change is best seen in periosteal sarcoma, the growth shrinking very greatly, and becoming devoid of malignancy.

Sarcomata of the naso-pharynx and tonsil are particularly suitable for radium treatment, and frequently disappear almost completely within three or four weeks of the exposure.

Lympho-sarcomata, and mediastinal growths of a lympho-sarcomatous character also exceedingly well, and with suitable dosage rapid absorption of the growths occurs.

This absorption, however, produces a very pronounced auto-toxæmia, and patients have therefore to be advised of the probability of this occurrence.

Endotheliomata.

These growths appear to occupy a position midway between carcinomata and sarcomata as regards their susceptibility to the action of radium.

Endothelioma of the parotid is possibly the most common of endotheliomata, and as many patients refuse operation by reason of the possibility of interference with the facial nerve if excision be performed, a fair number of these cases have been treated with radium. Encouraging results have been obtained, the size of the tumors has been much reduced, the condition rendered quiescent, and no metastases have occurred. It is advisable first to try the effect of treatment with external screened applicators only, and not to resort to the burying of emanation tubes unless no effect has been produced.

Melanomata.

These growths, by reason of their extreme malignancy and the rapidity of these disseminations, which occurs both through the lymphatic channels and the blood stream, are not very amenable to radium therapy. Diminution or even disappearance of the primary lesions may sometimes be obtained by the employment of a destructive reaction, but very little if any effect appears to be exerted in the arresting of the spread of metastatic deposits. As pigmented moles, which may have existed harmlessly for many years, not infrequently prove the starting point of melanomata when subjected to chronic irritation, it is advisable to deprecate very strongly any attempts to remove such lesions with radium. If their removal for any reason be imperative, a free and wide excision should be performed.

Rodent Ulcer.

It may now be accepted as an axiom of radium therapy, that rodent ulcers not exceeding 3 cm. in diameter, which have not been subjected to any previous treatment, and do not affect bone cartilage or mucous membrane, can be quickly and effectively removed by radium.

Unscreened treatment with full-strength applicators should be given the exposures being of from one and a half to three hours' duration, according to the size, shape and character of the lesion. It is better to err on the side of over exposure rather than under exposure, and to treat an area slightly larger than the growth, as in this way the probability of recurrence is very greatly diminished, and one such exposure usually suffices to effect a cure.

In cases of long standing where there is much surrounding induration, and the tissues have been devitalized by repeated cauterization, X rays, or CO_2 snow; prolonged exposures with heavily screened apparatus give better results, but the patient has to be kept under close observation for some time to come. When once mucous membrane, cartilage, or

bone have become definitely affected, the therapeutic power of radium is much lessened, and, more especially in the case of bone implication, surgical measures should be employed to remove the actively diseased areas.

Lymphadenoma

This condition generally exhibits an exceedingly favorable response to radium therapy, more especially when the superficial lymphatic glands only are affected, and there is no enlargement of the spleen appreciable. Prolonged exposures with a large amount of radium, 300 to 500 mgr. heavily screened, should be employed, and the series of exposures repeated at intervals of two or three months.

The immediate effect of these exposures is often the production of an auto-toxæmia which causes some systematic disturbance, lasting for about a week. The diminuation in size of the affected glands takes place at a very rapid rate, their disappearance occurring within four weeks of the exposure.

The probability of recurence is, however, great, and for this reason the patients should be kept under careful observation.

Cases.

Case No. 2088, M., aged 4. This child was first seen on the 1st May, 1916, the condition then having existed for two years. Examination revealed numerous enlarged, elastic, discrete, freely movable glands in the cervical triangles of both sides.

Some ill-defined masses of glands could be felt on deep palpation of the abdomen, situate principally to the right of the lumbar spine. The liver was enlarged, its lower border being 3 cm. below the costal margin. The spleen was not enlarged. The axillary and inguinal glands were not affected. The belly was distended, and the superficial abdominal veins dilated and conspicuous. There was a slight amount of ascitic fluid present, and the feet and ankles were œdematous. The child was anæmic, fretful and languid.

He received in all six series of prolonged screened exposure at intervals of two or three months, the last one being given in July, 1917. Great and permanent benefit resulted, though there were occasional exacerbations and remissions during the treatment. The child was last examined in April, 1918. No enlarged glands could be felt in either cervical triangle, and the masses of abdominal glands were very much smaller. The distension of the abdomen was but trifling, and there was no ascites nor œdema. No enlargement of either the liver or spleen was appreciable. The child was of good color, cheerful and active.

No further radium treatment has been given, but the patient has received occasional X-ray exposures during the past year. A report received early in 1919 stated that the child was in excellent health.

Case No. 2775, M., aged 23. This patient was a prisoner of war in Germany from November, 1916, to August, 1917, when he succeeded in effecting his escape. He stated that he first noticed some swollen glands at the left side of his neck in July, 1917. Whilst escaping from Germany he suffered much from fatigue, exposure and lack of food, and after his return to England in September the swelling rapidly increased. Early in 1918 one of the glands from his left supra-clavicular fossa was excised, and examined microscopically: report, lymphadenoma. Radium treatment was advised.

The patient was first seen at the Institute on the 28th March, 1918. He was a man of exceptionally fine physique, but very anæmic. The

glands in the cervical triangles of both sides were enlarged, firm, elastic, discrete and movable. The circumference of the neck was much increased, and patient stated that he had to take collars which were 2 inches larger than before his illness. The glands in both axillæ were slightly enlarged and definitely palpable. The inguinal glands were not affected, and there was no enlargement of liver or spleen.

X-ray screening showed a definite shadow in the superior mediastinum, extending for 3 cm. on either side of the sternum. The patient had practically no pain, but felt very languid and was easily tired. He had occasional attacks of respiratory embarrassment at very long intervals.

During the first week in April he received thirty hours' exposure with apparatus containing over 400 mgr. of radium screened with 2 mm. of lead, similar courses of treatment being given in May, September and November, 1918.

Great improvement resulted. The affected glands disappeared, the shadow in the mediastinum vanished, the patient regained his strength and energy, became of good color, and no longer suffered from any respiratory embarrassment. When last seen he expressed himself as feeling perfectly well, and was doing full duty.

LYMPHATIC LEUKAEMIA.

Case No. 6600, F., aged 70. This patient has been under observation for two years. Her health was good till the end of 1914, when she became pale, and in the summer of 1915 swelling of many of the lymphatic glands and dyspnœa were noted. In September, 1196, ascites and œdema of the lower extremities appeared.

When first seen in February, 1917, she was thin and pale, with severe dyspnœa on exertion. Enlarged soft glands were found in both axillæ and groins, and formed a large mass in the right supra-clavicular fossa. The spleen was enlarged and extended for three fingers' breadth below the margin of the ribs, and the X-ray screen showed the liver pushed up at the right side; there was considerable ascites, and ædema of thighs, legs and feet. Microscopical examination of the blood showed appearances pathognomonic of lymphatic leunæmia.

Courses of treatment were given in February, March, May and July with improvement. The patient then went away for four months and returned in November in a condition closely resembling that when she was first seen, with a large prominent swelling in the right parotid region in addition. Further treatment was given in November, January, March and June, by which time all the glandular swellings and the ascites had disappeared, and the spleen had receded behind the ribs. There was still some œdema of the legs, but the patient felt well and had a healthy color and was leading an active life. She has remained under observation since, reporting at intervals of six to eight weeks, but further raying has not yet been required.

SPLENIC LEUKAEMIA.

Case No. 2874, F., aged 41. The patient came to the Institute for treatment on the 10th June, 1918, the disease then being of two years' duration.

She had been treated with quinine and arsenic and X rays, and the condition had been kept in check until May, 1918, when the spleen commenced to increase very rapidly. When examined the spleen was found to be greatly and uniformly enlarged, its lower border reaching to a finger's breadth below the umbilicus. Its surface was smooth, its sub-

stance hard, and the abdominal wall moved freely over it. The evidence obtained by examination of the blood was typical of splenic leukæmia. Patient received thirty hours' exposure with applicators containing 400 mgr. of radium screened with 2 mm. of lead. The reduction in the size of the spleen was most rapid and striking. Within one month it was but very little larger than normal, and two months later splenectomy was successfully performed. The patient made an uninterrupted and complete recovery.

(To be concluded)

THE TECHNIC OF THE AFTER-TREATMENT OF WAR INJURIES*

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Early in 1914 I treated, with radium emanation needles, a patient having an extensive scar on the wrist, due to an old deep burn, which caused a painful and rigid hand. In less than a week marked improvement in the utility of the hand resulted, due to some freeing of the tendons to the fingers, decreased tenderness, and general betterment of the nutrition of the hand as a whole (1).

In August, 1917, when attached to the Blackrock Military Orthopædic Hospital, Dublin, I started again to treat patients there with adherent scars, painful scars, stiff joints, especially in the fingers, the result of old tenosynovitis, etc. (2).

Since then, up to September, 1918, I have systematically treated about 300 military patients by the surface application of radium emanation, and it has been very exceptional not to produce rapidly some improvement, occasionally very marked improvement, in cases which often for long periods have been unaffected by other methods, such as massage, ionization, whirlpool baths, etc.

For three months, through the kindness of Major-General Sir Robert Jones, C.B., F.R.C.S., I had the opportunity of demonstrating to the Senior Staff of the Alder Hey Military Orthopædic Hospital, Liverpool, the effect of radium treatment on their patients, and, as a result, they have recommended that the treatment should be adopted as a recognized method. The following lecture embodies a short account of radium, the rationale of treatment, and the dosage I have employed, as at present carried out by my successors at Alder Hey and Blackrock.

General Consideration (3).—As X rays and the gamma rays from radium have the same physical properties, a knowledge of the former is a help in understanding the rationale of treatment by the latter.

The principal differences are that the gamma rays utilized from radium are much harder or more pentrating than X rays, and their dose can be more accurately estimated, as it depends on the constant properties of radium, and not on the variable conditions that result and affect the nature of the x-rays produced by an electric current passed through a vacuum tube.

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Fortunately, as radium itself is therapeutically inactive, the therapeutic effects attributed to it can be obtained by employing the comparatively valueless radium *emanation,* thus avoiding the risk of loss of the parent radium. Radium is in unstable element. In 1690 years half of a given quantity of radium will have disappeared, and in another 1690 years only a quarter of the original quantity remains. The period of a radioactive element is the time it takes half of it to transmute into another element; in the case of radium 1690 years.

When an atom of radium disrupts it gives rise to an alpha-ray, *i.e.*, an atom of helium, and an entirely new element, the gas radium emanation. Radium emanation ejects an alpha-ray and becomes a solid radium "A," which turns similarly to radium "B," and so on, with some variations in the nature of the rays given off by the different bodies, till the element radium "G," is formed, which cannot be chemically distinguished from lead. It is the energy set free when radium "B" and radium "C" are breaking down which produces the therapeutic effects. It is, therefore, immaterial whether a radium salt or radium emanation is employed as a sources of this energy, except that the period of the latter is 3.85 days, its activity diminishing rapidly, while that of radium is practically constant. The period of radium "A" is 3.0 minutes, radium "B" 26.8 minutes, and radium "C" 19.5 minutes.

Radium Emanation is a heavy gas, atomic weight 222. It is usually collected from an acidulated watery solution of radium chloride with the aid of a mercury vacuum pump, and, like any other gas, will diffuse evenly through a vessel of any shape. Its collection is a tedious process, requiring special apparatus and the services of a physicist. It ran be obtained from radium institutions The London Radium Institute supply it for surface application in metal boxes, the Royal Dublin Society Radium Institutes in glass capillaries about 2 centimetres long, and fine enough to fit into a serum needle with a 0.8 millimetre bore. For general use these capillaries are the most convenient, as they can be arranged in metal boxes of any shape or size for surface application, or buried separateiv in needles, or collectively in metal tubes, or distributed along a catheter. The measurement of the activity of emanation is made by comparing its effect (*i. e.*, the rate of the fall of the gold leaves) on a Rutherford's gamma-ray electroscope with a known quantity of radium in a sealed tube which has been measured against a standard in the Physical Laboratory at Kew. One *curie* of radium emanation is the quantity in equilibrium with, and has the same therapeutic and ionizing effect as a gramme of radium element. It occupies half a cubic millimetre under standard conditions.

From what has been stated above in reference to the period of emanation, it follows that from a vessel containing 100 mg. of radium element in solution, about 50 millicuries can be drawn off every four days.

Therapeutic Agent.—The energy liberated on the disruption of radium "B" and radium "C" with their transmutation to radium "C" and radium "D" respectively.

Form of Energy—Gamma-rays, *i. e.*, light rays similar to X rays, with a wave-length of one ten-thousandth of that of ordinary light. (2) Beta rays, *i.e.*, electrons similar to the cathode rays of an X-ray tube.

Source of Energy.—A radium salt, or more frequently, radium emanation.

Physical Effect of Radium Treatment (in moderate doses on normal cells and tissues) :—

Increased metabolism of cells.
Improved nutrition of parts.
Stimulation of nerves and muscles to perform normal functions.
The absorption and freeing of scar tissue.
The softening of fibrous adhesions due to sepsis and disuse in synovitis and teno-synovitis.
Analgesic effect.

Rationale of Dosage.—Radium treatment is a variety of light treatment, and its dose may be compared in a very general way to the taking of an ordinary photograph. A photograph may be taken by a short exposure in a very strong light, or a long exposure in a dull light. If some of the light rays are cut off by a colored glass (compare screening), the exposure must be correspondingly lengthened. If a certain effect is produced on a photographic plate by a 100 candle-power light in one hour (100 by 1 = 100 candle-power hours, the same effect may be approximately by a 10 candle-power light in 10 hours (10 × 10 = 100). If a colored glass is interposed, which reduces the light to a quarter, the exposure should be four hours 100 × ¼ × 4 = candle-power hours). With both ordinary light and radium experience has shown that a more powerful effect is produced by a strong light and a short exposure than with a weak light and a long exposure.

If a light decreases in candle-power at a uniform rate (in geometrical proportion in the case of radium emanation) the dose may be measured by the loss of candle-power instead of in candle-power hours.

The measurement of a dose of radium depends on:—

1. The quantity of radium or emanation employed.
2. Its concentration, or the area over which it is distributed.
3. The amount of screening or filtering interposed.
4. The length of exposure.

The exposure is shortened as 1 and 2 are increased and lengthened as 3 is increased.

Definition of Standards of Measurement.—One milligramme of radium element has the same activity, ionizing power, and therapeutic value as—

(*a*) 1 millicurie of radium emanation.
(*b*) 1·81 mg. Ra Br_2 $2H_2O$
(*c*) 1·723 mg. Ra Br_2
(*d*) 1·474 mg. Ra Cl_2 $2H_2O$
(*e*) 1·315 mg. Ra Cl_2
(*f*) 1·424 mg. Ra SO_4

Milligramme hours or millicurie hours means the number of milligrammes of radium, or the average of the amount of emanation employed, multiplied by the number of hours they are in use. Thus, a dose of 100 millicurie hours may be administered by an average of

100 millicuries in 1 hour = 100 × 1 = 100 mch.
50 " in 2 hours = 50 × 2 = 100 mch.
10 " in 10 hours = 10 × 10 = 100 mch.

By the average amount of emanation is meant the mean of the initial and final amount of emanation present, or the amount present at half time in the exposure.

A readier method of finding the length of exposure required when

using emanation is by coming off on the present writer's emanation table (4), which gives the hourly decrease of its activity, the number of hours it takes for a certain quantity of emanation to dissipate.

For instance, the table shows that 82·9 millicuries and 23·5 millicuries each lose 1·2 millicuries in 2 and 7 hours respectively. Both amount approximately to 162 millicurie hours. It is more convenient to speak of a dose of 1·2 millicuries, and easier to find the time required to give it by counting lines on a table than by a calculation of millicurie hours.

Recording of Dose.—For accurate work in radium treatment it is essential to have an accurate method of recording the dose of emanation. By utilizing the emanation table, the above doses may be recorded as (5):—

$$82{\cdot}3 \times 2 = 164{\cdot}6 \text{ millicurie hours.}$$
$$23{\cdot}0 \times 7 = 161{\cdot}0 \quad " \quad "$$

or more conveniently as:—

$$82{\cdot}9 - 81{\cdot}7 = 1{\cdot}2,\ 2.$$
$$23{\cdot}5 - 22{\cdot}3 = 1{\cdot}2,\ 7.$$

The latter statement shows on the left side the initial and final amount of emanation present during the treatment, and on the right side the number of millicuries used up and the number of hours required for the dose.

The number of skin areas, say four on which surface application was made is conveniently included, thus:—

Millicuries starting	Less.	Millicuries finishing.		Millicuries used up.	No. of Skin areas.	No. of hours in use.
82·9	—	81·7	=	1·2	(4)	2

Rationale of Screening or Filtering off Soft Radium Rays.—The soft, or non-pentrating rays of radium (or X rays), will only act on the skin, and not penetrate to the deeper parts. Therefore, if they are not absorbed by some material, such as lead and cotton wool, interposed between the radium and the skin, the latter will receive an over-dose, while the deeper parts which require treatment are quite inadequately radiated. By using only hard rays the skin and deep parts are more uniformly radiated. The sequelæ of over-dose occur from three or four days to three weeks after treatment, according to the softness of the rays causing them and the amount of over-dose. The harder the rays and the less the over-dose the longer delayed is the reaction. Doses causing erythema, blistering, or superficial ulceration of the skin are sometimes necessary, but are better avoided for present purposes. They disappear quickly with a dry dressing or a simple ointment. Over-dose, causing deep burns and necrosis are very intractable, and must be avoided.

Clinical Consideration in Dosage.—Rays from radium come out in every direction, and the intensity of radiation, according to the distance from their source, is governed by similar laws as light. Hard gamma rays will traverse the whole human body, some of them several human bodies together. Therefore, when radium is applied to opposite sides of a limb, this fact must be taken into consideration, and the dose per skin area reduced somewhat, especially in the case of thin parts, as the fingers and hand. For the same reason, when adjacent skin areas are treated, the dose per area should be less especially in the central areas. As in the case of septic infection, bulky parts, as the thigh and arm, where there is more accommodation for vascular changes, will stand a larger dose than the hand, the immediate neighborhood of the knee, and over subcutaneous bone generally. Then parts affected by trophic changes should be given small doses.

Dosage According to Object of Treatment.—The largest doses are required to free scar tissue, due to the physiological organization of granulation tissue following gunshot wounds and sepsis. About half this dose is adequate to deal with the adhesion in joints and round tendons. For a purely anagesic effect on a tender scar, where the nerve endings are involved, an eighth or less of the full dose is usually sufficient.

Standard Applicator used by the Present Writer.—A lead box, consisting of two shallow trays fitting into each other, made of 4 lbs. to the square foot commercial lead sheeting, containing radium emanation in glass capillaries.

Measurements.—Lead, 1·57 mm. thick.
Area of bottom of box, 2 by 3 cm.
Depth, ·3 cm.

The box is completely surrounded by six layers of paper, 2 to 3 mm. thickness of cotton wool, and the whole made into a packet, about 4 by 5 cm., with sticking plaster.

The lead cuts off all the soft rays from the radium, while the covering is absolutely essential to cut off secondary soft rays produced in the lead by the rays from radium.

Dose of Radium Emanation for Surface Application.—I have found by experience, in cancer cases, that by using the applicator described over one area of skin, epilation, erythema, or ulceration of the skin will occur in from a fortnight to three weeks if the emanation is left on till its activity has been reduced by 3·2 millicuries, for convenience called a dose of 3·2 millicuries. A dose of 3·2 millicuries is, therefore, a safe dose for one area of skin in most circumstances.*

Skin with trophic changes, due to nerve involvement, is very susceptible to radium burns, and a third to a half of this dose should be the maximum.

Dose of radium emanation for surface application, using standard screen:—

1·5 mm. lead, wool, etc., area, 2 by 3.
Distance from skin, ·5 cm. (due to wool, etc.)
Dose causing ulceration, 3·2 millicuries.

For the Treatment of Gross Scars:—

Arm, forearm, thigh, leg—Over one area of skin, 2.2 to 2·5 mc.; over adjacent areas of skin, 2·8 to 3·2 mc.; over three adjacent areas of skin, 3·2 to 4 mc.; over four adjacent areas of skin, 4 to 5 mc.; over five adjacent areas of skin, 5 to 5·5 mc.; over six adjacent areas of skin, 5·5 to 6 mc.

Knee, elbow, and ankle.—Over one area, 2 to 2·2 mc.; over two adjacent areas, 2·5 to 3 mc.; over three adjacent areas, 3 to 3·5 mc.; over four adjacent areas, 3·5 to 4 mc.; over 5 adjacent areas 4 to 4·5 mc.

On hand and feet.—Over one area, 1·5 to 1·7 mc.; over two adjacent areas, 4 to 4·5 mc.

N. B.—In cases of hand and feet and thin forearms, skin surfaces diametrically opposite one another, should be considered as adjacent areas.

*Note—In the author's method of reckoning dosage the following relations obtain approximately with reference to the ordinary terms of milligram hours. 0.5 equals 70 mgm. hrs.; 1 equals 135 mgm. hrs.; 2 equals 270 mgm. hrs.; 3 equals 400 mgm. hrs.; 4 equals 550 mgm. hrs.; 5 equals 690 mgm. hrs.; 6 equals 840 mgm. hrs., etc.—Editor.

For the Treatment of Old Teno-synovitis and Adhesions due to Injury and Disuses:—

Hand.—Between fingers, ·3 to ·7 mc. each inter-digital space, total, 1 to 2·1 mc.; two areas palm and two areas back of hand, ·5 to 1 mc. each, total, 2 to 4 mc.; front and back of wrist ·6 to 1·6 mc each, total, 1·2 to 3·2 mc. Total for hand and wrist, 4 to 9·5 mc.

Elbow, 3·5 mc. for three areas; 4 mc. for four areas.

Shoulder, 6 mc. for five areas.

Knee, 7 mc. for seven areas.

Ankle, 4 mc. for four areas; 4·8 mc. for five areas.

Foot, 3 on dorsum, 3 on plantar surface. Total, 4·5 to 5 mc.

For tender scars, due to involvement of nerve endings, 0·5 to 0·7 mc. per area of skin. Similar doses should be given over nerves and nerve plexuses and arteries with their sympathetic nerve supply, in the neighborhood of wound scars, with the object of stimulating nerves to perform normal functions and to overcome what may be called, for want of a better term, "partial nerve block."

Interval at which Treatment may be Repeated·—For Scars, after four to six weeks· Four treatments in six months.

For painful scars, after two to five weeks.

For teno-synovitis hand, with 4 mc. dose. Repeat in fourteen days, twenty-one days, twenty-eight days, and every month, until six doses administered. With 9·5 mc. dose, as for scars.

NOTE·—Except where there is extensive and deep scarring, as in the thigh, where fairly large doses are required, apparently as good results may be obtained by small doses, more frequently repeated, as with large doses. On the whole, it is a mistake to think that the best results will be obtained by maximum doses, and it is better, when in doubt, to decrease the dose in military orthopædic cases, when one is not dealing with malignant tumors, or even benign growth, like keloids, but with cells and tissues which are the normal sequalæ of inflammation directly or indirectly due to trauma.

(1) Walter C Stevenson. "Preliminary Clinical Report on a New and Economical Method of Radium-therapy by means of Emanation Needles." *British Medical Journal,* July 4th, 1914; *Medical Annual,* 1916.

(2) "Radium Treatment of Scars, with Clinical Notes on Military Orthopædic Cases'" *Lancet,* March 23rd, 1918.

(3) "Radiotherapy in Gynæcology, chap. xviii., page 300 "A Practice of Gynæcology," by Henry Jellett, M.D., F.R.C.B.I. Fourth Edition.

(4) "A Convenient Radium Emanation Table for Clinical Work," ARCHIVES OF RADIOLOGY AND ELECTROTHERAPY, March, 1916; *Medical Press and Circular,* April 19th, 1916.

(5) "A Method of Recording Radium Doses," ARCHIVES OF RADIOLOGY AND ELECTROTHERAPY, January, 1916; *Medical Press and Circular,* December 8th, 1915.

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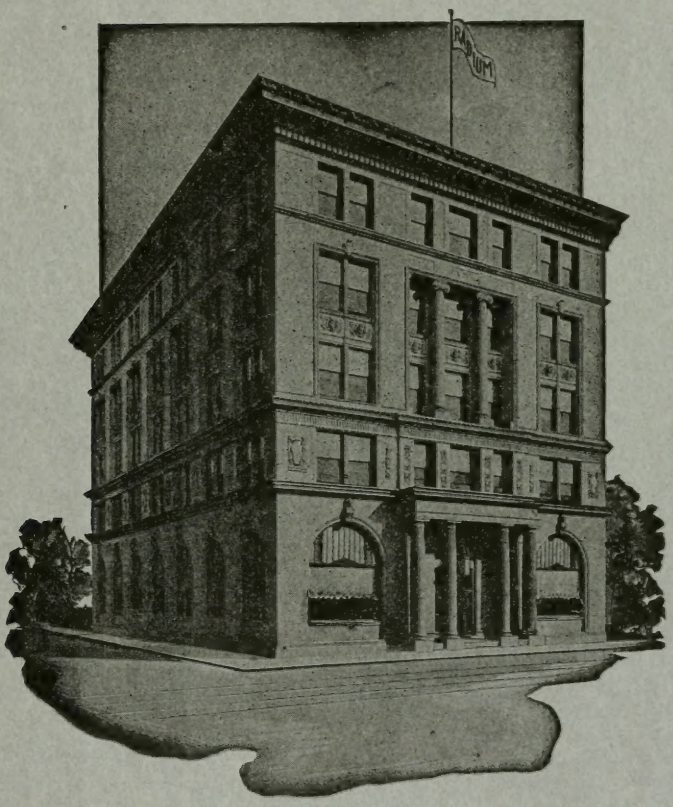

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